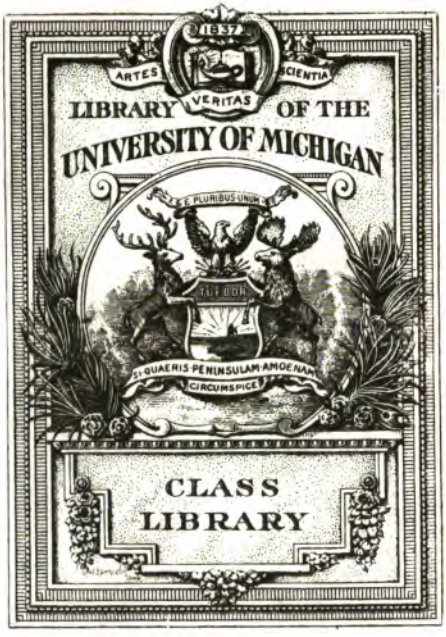

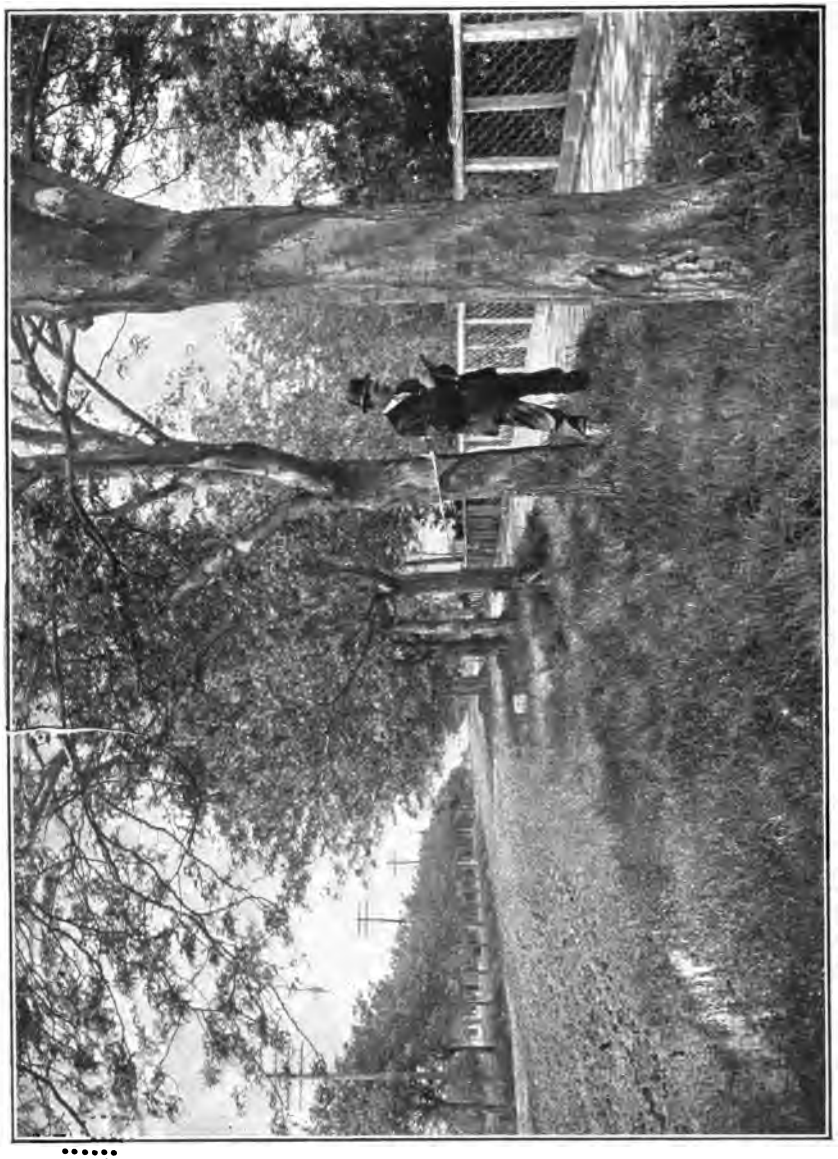

THE HONEY LOCUST AS A STREET TREE, OSBORNE, KANS.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF FORESTRY—BULLETIN No. 52.
GIFFORD PINCHOT, Forester.

FOREST PLANTING IN WESTERN KANSAS.

BY

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1904.

BUREAU OF FORESTRY.

GIFFORD PINCHOT, *Forester.*

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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF FORESTRY,
Washington, D. C., June 28, 1904.

SIR: I have the honor to transmit herewith a report entitled "Forest Planting in Western Kansas," by Royal S. Kellogg, forest agent in the Bureau of Forestry, and to recommend its publication as Bulletin No. 52 of the Bureau of Forestry.

The map and seven plates accompanying the text are necessary for its proper illustration.

Very respectfully,

GIFFORD PINCHOT,
Forester.

Hon. JAMES WILSON,
Secretary.

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FOREST PLANTING IN WESTERN KANSAS.

INTRODUCTION.

The investigations upon which this report is based were made for the purpose of determining the kinds of forest trees best adapted to western Kansas and the methods of treatment which have proved most successful. Since there is little likelihood that more than small local areas of the region can ever be irrigated, only the species which can be grown without irrigation are described. With an artificial supply of water better results can be obtained with these species, and others that could not be grown without it can be introduced.

Whatever may be the reasons for the absence of natural forests on the Great Plains, a close study of established plantations proves that, with an intelligent selection of species and proper care, planted trees can, to a considerable extent, be made to supply the deficiency.

It is generally accepted that for the most successful agricultural conditions from 10 to 25 per cent of the land should be forested. There is little likelihood that this proportion will ever be attained in western Kansas. Yet the planting that will come as the State increases in age and wealth will be sufficient to exercise a marked effect on the landscape, and to supply wood for many domestic purposes. In favored localities commercial returns may be expected; elsewhere the recompense to the planter will take the form of increased comfort and convenience. The American has in many regions ruthlessly destroyed his natural forests, but with characteristic energy he is creating woodland where none existed before. As a result of past attempts, sufficient data are at hand to justify fairly certain conclusions as to how far and under what conditions forest planting is practicable.

On the Plains the most extensive early plantings were made to secure title under the timber-culture law. They generally resulted in failure because of poorly chosen species and neglect. The man who made a timber-culture filing did so to get 160 acres of land, not because he cared for trees, or had sufficient experience to grow them. If he could evade the law and "prove up" without any trees whatever, he was altogether too likely to consider himself that much ahead. There were some well-planted and conscientiously cared-for claims, which now speak for themselves. The majority, however, amounted to little or nothing. After various modifications, the law was repealed in 1891.

The landowner now plants because he wants trees. Consequently he is careful in his choice, and gives more after attention than did his predecessors.

TERRITORY COVERED.

The region most closely examined for this report was that part of the State westward of the ninety-ninth meridian, which passes near Kearney, Nebr., along the western edge of Smith, Osborne, Russell, Barton, Stafford, Pratt, and Barber counties, in Kansas, and a few miles west of Alva, Okla. But since the State boundary is wholly artificial, the conclusions reached apply equally well to neighboring portions of other States. The study may therefore be said properly to cover the territory lying between the Platte and the Cimarron rivers, and between the ninety-ninth and one hundred and third meridians. It thus includes a little of northern Oklahoma, a considerable strip of eastern Colorado, and a portion of southwestern Nebraska.

PHYSICAL FEATURES.

This region is a part of the long eastward slope from the Rocky Mountains called the "Great Plains," and on the west includes much of the subdivision which geologists have named the "High Plains." The altitude runs from between 1,500 and 2,000 feet on the eastern border to 4,000 and over on the western. Although the rise is so uniform as to be scarcely perceptible, with the increasing elevation and diminishing precipitation fewer forest species can be grown successfully.

The geological formations are mostly Cretaceous and Tertiary. The former are exposed on the east, but are overlapped by the latter westward. Rock, where it occurs, is generally limestone, with occasional beds of sandstone. Though rock is often abundant in the bluffs, cultivated fields are uniformly free from stone or gravel.

The principal rivers are the Republican, Solomon, Saline, Smoky Hill, and Arkansas. Smaller tributary streams and creeks are quite numerous.

The soil on the uplands is generally of the type named by Professor Hay "plains marl," and has great depth and fertility. Much of the soil in southern Nebraska is loess, the good qualities of which are well known. In Oklahoma and southern Kansas occur the strikingly red sands and clays of the Red Bed formation. Valley soils are frequently loamy sand or sandy loam along the main streams, and of still heavier composition in the minor creek bottoms. Correlated with this difference in soil between the main and tributary streams is the noticeable preponderance of natural timber along the latter. Along the south side of the Arkansas a belt of sand hills is generally found, narrow in the upper part, but widening to some 30 miles south of Great Bend. Small sandy areas occur in various places.

BUREAU OF FORESTRY, U.S. DEPT. OF AGRICULTURE. NO. 143

WESTERN KANSAS AND ADJACENT REGIONS.

Since soil conditions are very uniform, only the types of location based on relative situation, viz, valley and upland, are used in this report. Valley or lowland areas are those along streams, where permanent water exists at not more than 25 feet, a depth beneath the surface not too great for trees to be benefited by it. The upland areas comprise the main part of the region. On them the tree roots never reach water, which is often 100 to 200 feet below the surface.

A sandhill region has more in common with the valleys than the uplands, even when its situation is relatively high. Few people realize how much moisture a sandhill soil contains. There is practically no surface run-off; all the water which falls sinks into the ground. The soil never bakes, but is always in a receptive condition. The evaporation is less than from a clay soil, and a larger percentage of the moisture is available for plant use. The cottonwood and the sandbar willow are found growing naturally in the sandhills of Kansas and Nebraska, which is evidence that good conditions of soil moisture exist. The sandhills, therefore, are favorable localities for tree planting.

CLIMATE.

The climate of western Kansas is ordinarily classified as subhumid or semiarid. Its chief characteristics are those common throughout the Great Plains. The average annual precipitation is sufficient for paying crops. The distribution, however, is subject to great fluctuations. The summer rainfall comes mostly from local thunder storms, whose erratic courses may or may not overlap. Consequently one locality often receives enough rain during the season, while another a few miles away suffers from drought.

There is also a marked tendency to a succession of wet and dry seasons over the entire region. This is well illustrated by comparing the records at Dodge for 1883 and 1884 with those for 1893 and 1894. It happens that there is a ten-year period in this case, but observations do not prove any regular periodicity.

Annual precipitation at Dodge, Kans.

Year.	Inches.	Departure from normal.
1883	28.50	+ 8.12
1884	30.36	+ 9.98
1893	10.12	−10.26
1894	12.60	− 7.78

The wet years of 1883 and 1884 were largely responsible for the "boom," which resulted in the rapid settling up of the country between the years 1885 and 1887, while the dry seasons of ten years later caused wholesale depopulation.

The average precipitation at the principal Weather Bureau stations, with the number of years that the record has been kept, is given in the following table:

Average annual precipitation.

Station.	Years.	Inches.	Station.	Years.	Inches.
Wallace	22	17.42	Hays	10	20.88
Lakin	12	14.35	Achilles	10	20.94
Colby	11	17.49	Phillipsburg	11	21.89
Viroqua	10	18.83	Medicine Lodge	10	23.57
Eureka Ranch	12	18.92	Pratt	7	23.78
Garden City	8	18.92	Oberlin	10	23.80
Dodge	28	19.84	Average		19.78
Gove	13	20.37			
Englewood	10	20.71			

While the record at Dodge is the only one covering a sufficient period to be considered approximately correct, the others are good indications, and it may be assumed that the average for the entire region is not far from 20 inches. With this may be compared 26.32 inches, the average annual precipitation for the middle of the State, and 34.33 inches for the eastern part.

It is noteworthy that most of the precipitation on the Plains is during the growing season. Dodge, for instance, with only 19.84 inches annually, has 15.5 inches in the six months from April 1 to October 1. Rochester, N. Y., with 35 inches annually, has but 17.5 during the same period. In other words, 78 per cent of the precipitation at Dodge comes at the time when it is most needed, while Rochester receives but 50 per cent of its total in the same time.

One of the most disagreeable characteristics of the climate of the Plains is the high winds, which sweep across them unhindered by either natural or artificial barriers. The prevailing direction is northwest in winter and southerly in summer, and soil moisture is absorbed with extraordinary rapidity, especially in the warm season. The dreaded "hot wind," which strikes growing crops with such deadly effect, is a hot, dry blast of air that takes water from the leaf surfaces of vegetation faster than it can be supplied by the roots; consequently plants wilt and even die if the wind is long continued. The northerly winter winds, while causing much less evaporation, are hard upon stock and trying for men.

The average wind velocity at Dodge City, Kans., is 12 miles per hour. In spring, however, it is considerably higher, especially in the afternoon hours, when an average speed of 20 miles an hour may be maintained for a month at a time. High winds are also quite frequent. In the ten years ending with 1903 there were eighty-one occasions on which the wind blew at the rate of 40 miles and upward an hour.

As a result of these constant drying winds, taken in connection with the meteorological conditions which prevail in western Kansas, the annual evaporation from a water surface is about 54 inches. This means that if it were possible to have a lake in western Kansas whose level depended wholly upon direct precipitation and evaporation, its annual decrease in depth would be 34 inches. The relative humidity, according to the Dodge record, averages 60 to 65 per cent. The following table is especially instructive:

Annual precipitation and evaporation.

Station.	Precipitation.	Evaporation.	Excess of evaporation.
	Inches.	*Inches.*	*Inches.*
Amarillo, Tex	21.94	55.40	33.46
Dodge, Kans	19.84	54.60	34.76
North Platte, Nebr	18.27	41.30	23.03
St. Vincent, Minn	19.50	22.10	2.60

Thus it will be seen that the great wheat-growing district of the valley of the Red River of the North has a precipitation practically identical with that of western Kansas, and slightly less than the Staked Plains of Texas. The southern region, however, has more wind, higher temperature, greatly increased evaporation, and a more uneven distribution of rainfall. These are adverse conditions for planting and growing trees, and to overcome them requires an intelligent selection of species and a system of cultivation which reduces the evaporation of soil moisture to a minimum.[a]

EFFECT OF FORESTS ON CLIMATE.

Many of the residents of the Plains region believe that increased cultivation of the soil, forest planting, and the building of reservoirs to catch storm waters will cause a permanent increase in the precipitation. But this theory is unsupported by proof. The records that have been kept long enough to warrant any general conclusions indicate simply wet and dry periods of variable length, which result in a fixed average precipitation. Much has been said concerning the effect of forests on climate, but little is known exactly, and most of what is known contradicts the popular beliefs. The heaviest rainfall in the world occurs in regions that are densely forested, but the rain undoubtedly causes the forests, not the forests the rain. The most that can be

[a] For a detailed discussion of the climate and geology, the reader is referred to publications of the U. S. Weather Bureau, and the paper, "The High Plains and Their Utilization," in Vol. IV of the Twenty-first Annual Report of the U. S. Geological Survey.

said from the facts at hand is that an increase of precipitation by forests is not demonstrated. Even were it otherwise, planting sufficient to affect general climatic conditions would need to be on so large a scale as to be wholly impracticable.

On the other hand, observations show that within the forest extremes of both heat and cold are modified, and that the evaporation from a water surface is less than one-half that in the open, while the evaporation from soil covered with forest litter is about one-eighth that from bare fields. Forests check the run-off to a great extent. The amount of water transpired by a forest is considerably less than that given off by a similar area of ordinary agricultural crops.

These facts point to conclusions about which there is no doubt. Forests are conservers of moisture. They are the best natural means of saving the water that falls, and are of great utility for this reason, regardless of their problematical effect upon the amount of precipitation.

The principal effect of tree planting on the climate of western Kansas will be to check the winds and lessen evaporation in the immediate vicinity of the plantation.[a]

SHELTERBELTS AND WINDBREAKS.

The terms "shelterbelt" and "windbreak" are often used interchangeably. When distinguished, shelterbelt is applied to trees planted in groups of considerable size, while one or two rows to check the wind is called a windbreak. Since this discussion applies equally well to both shelterbelts and windbreaks, the latter term is chosen for the sake of simplicity.

In an open country of high winds, nothing adds more to the comfort of existence than a protecting belt of trees about the home. Whether the wind be the hot one of summer or the snow-laden blast of winter, its force is spent on the trees, and the house within is not swept by every passing gust. Orchards need windbreaks to save them from injury in the gales that accompany summer storms as well as to protect them from ordinary winds throughout the year. Gardens are more successful when surrounded by trees. Windbreaks benefit animals as much as their owners. Evans Brothers, of Garden City, Kans., are planting trees about the board windbreaks in their winter pastures, and their example might profitably be followed by other ranchmen whose pastures are lacking in natural shelter.

Any species that is adapted to the region and suits the taste of the planter may be used for a windbreak. Where they will succeed, ever-

[a] An extensive discussion of the relation between forest and climate is found in Bulletin No. 7 of the Division of Forestry, U. S. Department of Agriculture, entitled "Forest Influences."

greens are desirable, since they afford better winter protection than the deciduous species. The man who wants a windbreak, however, does not care to wait for slow-growing trees. The Austrian and Scotch pines grow quite rapidly and serve the purpose well. A windbreak consisting of a single row, to be effective, should be of a densely-growing type that branches close to the ground. For low breaks of this character the Russian mulberry and Osage orange are excellent. The tamarix, while more like a large shrub than a tree, does well for low windbreaks around garden patches and similar areas. It is easily propagated by cuttings, grows rapidly, and is quite hardy. The tamarix is often called "tamarack," or "mountain tamarack," but these names do not properly apply to it. The cottonwood is the common tree used for windbreak purposes in the valleys.

One of the most important functions of the windbreak is the saving of soil moisture within the protected area. In the Monthly Weather Review for September, 1888, were published the results of experiments made by the United States Signal Service to determine the effect of the rate of wind on evaporation from a water surface. The experiments were made with a Piche evaporometer, under constant conditions of humidity and temperature. The figures obtained are given in the following table, in which wind velocity is expressed in miles per hour and the unit of evaporation is that in a calm:

Wind.	Evaporation.
5	2.2
10	3.8
15	4.9
20	5.7
25	6.1
30	6.3

A 25-mile wind is not uncommon on the Plains, and since it causes six times the evaporation that would occur in a calm at the same humidity and temperature, one can easily understand the rapidity with which the moisture from a summer shower disappears. Taken the year through, the wind averages more than 10 miles an hour, which is sufficient to cause four times the evaporation there would be in a calm.

An experiment made by King[a] furnishes some interesting information in regard to the checking of evaporation by a windbreak. He used a modified form of the Piche instrument, placed so as to give the evaporation from a water surface 1 foot above the ground at varying

[a] F. H. King, Bulletin No. 42, Agric. Exp. Sta., University of Wisconsin, October, 1894.

distances from an oak grove. Taking the evaporation at 20 feet from the grove as unity, the following results were obtained:

Distance.	Evaporation.
20	1.00
100	1.29
200	1.41
300	1.66

Neither the height of the grove nor the rate of wind is given, though the statement is made that a light wind was blowing. The table shows that the evaporation at 200 feet from the windbreak was 41 per cent more than at its base, and at 300 feet 66 per cent more. The evaporation from 300 feet onward was practically constant, showing that to be the limit of the influence of the windbreak in this experiment.

While a few accurate experiments have been made to determine how far a windbreak is effective, it is a safe practical assumption that it protects the ground for a distance equal to ten or fifteen times its height—some observers say a rod for every foot. If a large field were crossed by a series of windbreaks 30 feet high and 20 rods apart, there is no doubt that they would be very effective, since the wind would reach each succeeding break with diminished force.

WOODLOTS.

In many situations it will be a paying investment for the farmer to put out a small plantation, simply to produce his own wood for fuel and other purposes. It is true that some time must elapse before the plantation begins to be productive, but by choosing rapid-growing species and planting closely the thinnings which will be necessary in a few years, even though the trees be small, will do for the wood pile and help make the owner independent of coal famines. One may well be thankful if, when the supply of fuel gets low, he can go into his woodlot and cut a load without expense instead of hauling high-priced coal from the distant town.

The choice of species for a woodlot depends somewhat upon the location. Trees that grow rapidly, and at the same time produce good wood, are, of course, preferable. If they also sprout from the stumps, a little care will maintain the supply indefinitely. Where it succeeds, the black locust combines these desirable qualities in the highest degree, and, as mentioned further on, a proper method of handling will generally enable good results to be obtained despite the troublesome borer. The Osage orange also is an excellent tree for the woodlot. Its wood is exeedingly durable, and the sprout growth abundant. While it grows more slowly than the locust, it is hardier, and is free from borers,

so that it can be given more time in which to develop. Green ash, Russian mulberry, and hardy catalpa are also good trees for the woodlot, though the range of the last is more restricted than that of the other species.

A mixture of species is often advantageous. By its use differences in habits of growth and ability to withstand shade can be made to assist the development of trees of good form, and at the same time the owner can have both fast and slow growing trees and a wider choice of timber for varying needs. A mixed plantation of hardy catalpa and Osage orange or Russian mulberry has been found to be valuable, since the catalpa forces the Osage orange and mulberry to grow rapidly upward in order to obtain light, while itself shedding its lower branches in the denser shade of its neighbor sooner than it would if it grew by itself.

DETAILS OF PLANTING.

CONIFERS.

The best time for the planting of forest trees is in the spring, just before growth starts. This is also the best time for pruning, an operation which necessarily accompanies transplanting to a certain extent. Many people hold to the idea that evergreens should be set out in June or August. Evergreens can be successfully transplanted at any season of the year, provided sufficient care is taken. Coniferous trees transpire only one-tenth to one-sixth as much water as the broadleaf species; consequently their roots are not called upon to furnish such great quantities of water to the thirsty leaves before getting established in the new abode. For this reason pines and cedars do not require trimming back when set, and the time of the year is less important than with other species. Nevertheless, the best time for transplanting any tree is the dormant period, and there is no reason for making evergreens an exception to the rule.

Great care must be taken, however, to keep the roots moist in transplanting. If the resinous liquids in them once dry out, the tree will not live, no matter how abundant the subsequent supply of water. A young cottonwood may be dug up, shaken free from dirt, and thrown down in the sunshine for several hours without killing it, if the roots are given a good soaking when it is set. The same treatment of cedar or pine would insure death. Nursery stock often dies, either because it dried out on the road or because it was not properly cared for on arrival. Trees that have been shipped should have their roots dipped in a puddle of water and earth, about the consistency of cream, and should be planted as soon as possible. If the conditions are not favorable for planting immediately, they should first be puddled and then heeled in.

To heel in trees, a trench running east and west, and deep enough to hold the roots and about half the tops, should be dug, with its south bank making an angle of about 30 degrees with the surface of the ground. In this is put a layer of trees with the tops leaning to the south. The roots and lower part of the trunks are then covered with fine, firmly packed soil, and water is liberally poured on. In the same way successive layers may be put in until the trench is full. A temporary shade of some sort will lessen the danger of drying out. In the case of evergreens this is very important.

It is often asserted that the native red cedar is sure to die when transplanted; but such is not the case. The experience of a resident of McCracken, Kans., is instructive. He went to the bluffs of the Smoky Hill River, dug up a number of red cedars about a foot in height, immediately rolled the roots in a near-by mud puddle, and kept them moist until set. As a result every tree lived, and growth was scarcely checked. At the same time he received a shipment of cedar from a nursery, used equal care, and lost every tree. The nursery stock had dried out either before or during shipment, while the native trees had been properly handled. A very successful example of transplanted native red cedar is that on the grounds of the Indian school at the Pine Ridge Agency, S. Dak. The trees were dug up in the neighboring bluffs and set during a drizzly rain by the boys of the school, under the direction of the superintendent. Nearly all of the trees lived.

BROADLEAF SPECIES.

For plantations of broadleaf species 1-year-old seedlings are best to use, because they are easier to handle and also much cheaper than older trees. They ordinarily run from 1 to 2 feet high, and have practically no branches, so that little or no pruning is required. If the ground has been well prepared and is moist, the setting can be done very rapidly. A man and a boy can work together advantageously. The boy carries the trees and hands them to the man as wanted. The latter sets his spade full length in the ground, throws the handle forward, sticks a seedling in behind the blade, removes the spade, steps firmly with both feet on the ground around the tree, and the operation is complete, taking not more than half a minute in all. A number of seedlings can be carried in a bucket partially filled with water, or in a basket with a wet cloth covering the roots. The remainder of the stock should be left heeled in until needed. By this method a thousand trees can be set much more quickly than by the orthodox method of digging a hole, spreading the roots out, filling in with fine dirt by hand, and finally mulching; and with good soil and moisture conditions it is very successful. The writer set out over 500 yearling honey locusts in this manner on March 31, 1903. They were nicely started

when frozen back by the snowstorm of April 29, in spite of which all but three lived, and made an average height growth of 3 feet during the season. Similar results have been obtained with black locust, cottonwood, ash, elm, and mulberry.

Another rapid method is to plow a furrow where the row of trees is wanted, lay them against the side of it, cover with a hoe, and tramp firmly. The remaining dirt may be thrown into the furrow with a cultivator. Of course it should be distinctly understood that these methods are only for common broadleaf seedlings when the right conditions exist, and are likely to fail elsewhere.

For large trees much more care is necessary. Little top should be left—a heavy mass of foliage will transpire more water than the roots can supply at the start. Bruised or broken roots should be cut off clean. The roots should be well arranged in the hole and the dirt solidly tramped about them. Unless the earth comes into close contact with the roots, the air will get in and dry out both soil and roots, and the trees will die. If the setting is done in a dry time, water and puddling are necessary. A good way to water is to have the hole nearly filled with fine, firm dirt, then pour on the water and cover with dry soil. This prevents baking and evaporation.

Trees should be set so that when the ground settles into permanent shape the roots will be covered to the same depth as before transplanting. This means setting 2 or 3 inches below the "collar."

It is a good practice to set deep enough so that when the operation is completed the trees will stand in a shallow depression. This will catch the rain and materially increase the chances of success in a dry season.

An essential requisite in planting is suitable weather. Occasionally there are springs in western Kansas when it is altogether useless to set trees unless water can be supplied whenever needed. The planter who raises his own seedlings can take advantage of favorable conditions, have his trees perfectly fresh, and set when he pleases, or even let them wait until another season.

CUTTINGS.

Willows and cottonwoods and other poplars are very easily propagated from cuttings. Cuttings should be of strong, healthy wood of the previous season's growth, which ripened well and did not shrivel during the winter. A good length is 8 to 12 inches, with the upper cut just above a bud. They may be made when wanted for planting and set with a spade or in a furrow, as described for seedlings. If the ground is mellow, they can be merely shoved into the soil until only one bud is above the surface, and then tramped. Better soil contact is secured if they are put in slanting; the growth will be upright in

any case. In favorable seasons cottonwood cuttings often make a height growth of 5 or 6 feet.

Many tree planters hold that cottonwoods raised from cuttings are of inferior form to those raised from seedlings, and shorter lived. There seems to be much reason for this belief, though it is not apparent why cuttings should not produce good trees if the situation is favorable.

RAISING FROM SEED.

Such common species as ash, mulberry, Osage orange, black and honey locust, catalpa, and black walnut are easily raised from seed, and the person who intends planting a large area will find it both cheaper and more convenient to buy seed of some reliable house and raise his own trees.

To insure prompt germination the seeds of the two locusts are treated with hot water before sowing. A leading Nebraska nurseryman who is very successful with his seedlings pours water, at a temperature of 175° F. for honey locust or 120° F. for black locust, on the seed, and allows it to stand for several hours. The seeds which swell and rise to the surface are skimmed off and planted immediately, and the operation repeated with the remainder. Treatment with boiling water is often recommended, but tests indicate that in some cases, at least, the vitality is destroyed. There is no doubt that a safe and reliable method for the honey locust is to use water at an initial temperature of 25° to 50° under the boiling point, and then let the seeds soak in lukewarm water until they swell. Seeds which have become very dry must soak longer than those which are fresh. Black locust seeds grow very well without any treatment, but the use of hot water causes more uniform germination.

Heavy-coated seeds, like nuts and acorns, are best sown in the fall, so that they will be opened by the frost. Ordinary seeds may be sown in corn-planting time. The soil should be moist and well prepared. Only a shallow covering of earth is necessary. If the ground is dry, the sowing should be delayed until moisture comes.

With a good season the little trees will be of suitable size to transplant the following spring, and will not require much pruning. The great advantage in having home-grown seedlings is, that they are at hand and ready to take up and set where wanted any favorable day with little danger of drying out. Handled properly they will begin the second season's growth promptly, and with scarcely any check from transplanting.

Pine seeds germinate readily, but to avoid losing the young seedlings requires so much care for light and moisture conditions that the ordinary planter will do well not to experiment with them. The ger-

mination of the red cedar is one of the troublesome problems of nurserymen; so much so that many prefer to buy 1-year-old seedlings, which they transplant and prepare for their own trade.[a]

SPACING.

Spacing is largely a question of utility and taste, with some variation for different species. In general, however, closer planting is advisable on the Plains than most people imagine or are willing to concede. A single tree or row of trees in the sod has little show for life. If an artificial forest is to succeed in the struggle against native vegetation, wind, sunshine, and dry weather, it must stand in a dense mass and present a solid front to its foes. Cultivation is the best method of conserving soil moisture, and if cultivation can be continued indefinitely and the abundant pruning required to produce the proper form where the trees are not crowded can be given, rather wide spacing is beneficial; but the average planter will prefer a method which does not require so much time and work. The less care the trees are to have, the thicker they should be set. They must be close enough to establish forest conditions of shade, litter, and undergrowth when evaporation and weeds are no longer checked by cultivation.

Shelterbelts should be close planted in order to give protection quickly. It is well to plant thickly enough to be able to thin as the growing trees need more room. In this way one can be certain of having good trees. If the ultimate object is to have spaces 4 by 8, or 8 by 8, and the trees are set out 4 by 4, the poorer trees can be cut out and a final stand left of better individuals than if the wider spacing had been used at first. The crowding also prevents the trees from heading too low. The thinning will give fuel, posts, and stakes, always useful on a farm or ranch.

The practical consideration is the spacing of the rows in a manner that will admit ready cultivation with the harrow, disk, or other tool for surface cultivation which the farmer possesses. The method of wide spaces between the rows with trees set closely in them is an excellent one, since it permits of cultivation for a much longer time than the 4 by 4 spacing, gives room for a team and wagon when thinnings are made, and still allows a large number of trees to the acre. A 2 by 8 spacing gives the same number of trees per acre as a 4 by 4 spacing, and 3 by 8 the same as 4 by 6.

[a] For detailed and practical information concerning the treatment of all kinds of seeds and seedlings the reader is referred to Bulletin No. 29 of the Division of Forestry, U. S. Department of Agriculture, entitled "The Forest Nursery," which is sent free upon application.

The following table shows the number of trees per acre with various spacings:

Spacing.	Number of trees per acre.	Spacing.	Number of trees per acre.
Feet.		*Feet.*	
3 by 3..	4,840	2 by 8...	2,722
3 by 4..	3,630	4 by 5...	2,178
3 by 5..	2,904	4 by 6...	1,815
4 by 4..	2,722	5 by 5...	2,742
3 by 6..	2,420	4 by 8...	1,361
3 by 8..	1,815	8 by 8...	680

The number required for any system is found by dividing the number of square feet in an acre (43,560) by the product of the two dimensions. For example, the last number in the table, 680, is the quotient obtained by dividing 43,560 by 64.

COST.

The cost of planting is not great. At ordinary prices $1.50 per acre will cover the expense of plowing and harrowing. After the ground is prepared the planting of small broadleaf trees will cost about $2.50 to $4 a thousand, according to the method used and the soil conditions.

The planting of ground occupied by virgin sod is not only laborious and expensive, but is generally unwise. The treatment of such land requires the breaking of the sod, followed by a second plowing and the cultivation incident to the growing of cereal crops for two or three seasons, before the ground is in suitable condition for the planting of trees. Soils containing a large amount of sand can frequently be put into condition for planting the year following the breaking of the sod.

The price of broadleaf seedlings at the nurseries in Kansas and Nebraska runs from $1 to $6 per thousand. Some nurseries pack free and pay freight on orders amounting to $10 or more. The planter will do well to consult several catalogues before placing his order.

Evergreens are more costly, since they are transplanted in the nursery to give better root development, and may be several years old when finally disposed of. It is possible to obtain red cedar seedlings as low as $4 per thousand, but transplanted nursery-grown cedar and pine of suitable size will cost 10 to 20 cents each and more.

WHERE TO PLANT.

In a naturally treeless region there is occasion for planting almost everywhere. Houses, sheds, corrals, and garden patches need protection and ornament; planted groves will yield timber for posts, fuel,

and the numberless uses which a stick of timber supplies; in parks and along streets trees make a town "a good place to live in;" schoolhouse, church, and court-house yards require embellishment. A good plantation for commercial purposes will afford a steady income, aside from much pleasure and convenience, while it is surprising how greatly a few trees improve the farmstead.

Although general soil conditions vary little throughout western Kansas, there is abundant room for selection. Trees, like other forms of vegetation, respond quickly to good soil and moisture. The species which will grow on the uplands may be depended upon to do as well or better in the bottoms, because of the better conditions. Some trees which grow naturally along water courses do well under cultivation on the upland, while others found in company with the hardy species fail entirely when the change is attempted. Hundreds of failures in upland planting in Kansas and Nebraska have resulted because cottonwood, willow, silver (soft) maple, and boxelder were expected to thrive in dry situations.

Experiment has proved, however, that there are species suitable to use whatever the locality. On the upland there are local depressions which catch considerable run-off, and so are suited to trees which need more than the normal precipitation of the region. In such a situation on the high upland in the extreme western part of Kansas the writer once found, to his surprise, a row of black walnut growing in the sod, yet looking well and bearing nuts, though the settler who planted the trees had long since moved away and of his sod house only a heap of dirt remained. A cattle trail and wheel tracks served to conduct the rainfall down the gentle grade to the trees, permitting water to collect occasionally at this point. That the original plantation had covered a larger area was shown by a few small stumps farther on, which were all that was left to show the effect of drought and neglect. Nearly every quarter section has an acre or more of depressed land which can be well utilized for tree planting. By putting the moisture-requiring species in the favored situations and the hardy, drought-resisting ones elsewhere the planter's range of choice is extended, greatly to his advantage.

CULTIVATION.

The object of cultivation is, first, to prevent the growth of weeds and grass, and, second, to conserve soil moisture. Cultivation is essential for the first few years after planting, and in many cases necessary for a long period. Before trees are set or seed is sown the ground should be put in good condition. Deep plowing, followed immediately by the harrow, saves moisture and prepares the soil for penetration by the roots. After the trees are set, cultivation should be shallow and frequent. An ideal method is surface cultivation as soon as possible after every rain. The nearer this ideal is approached

the better the results will be. A dust mulch is the best of all mulches for saving the water already in the ground and keeping the soil receptive for more.

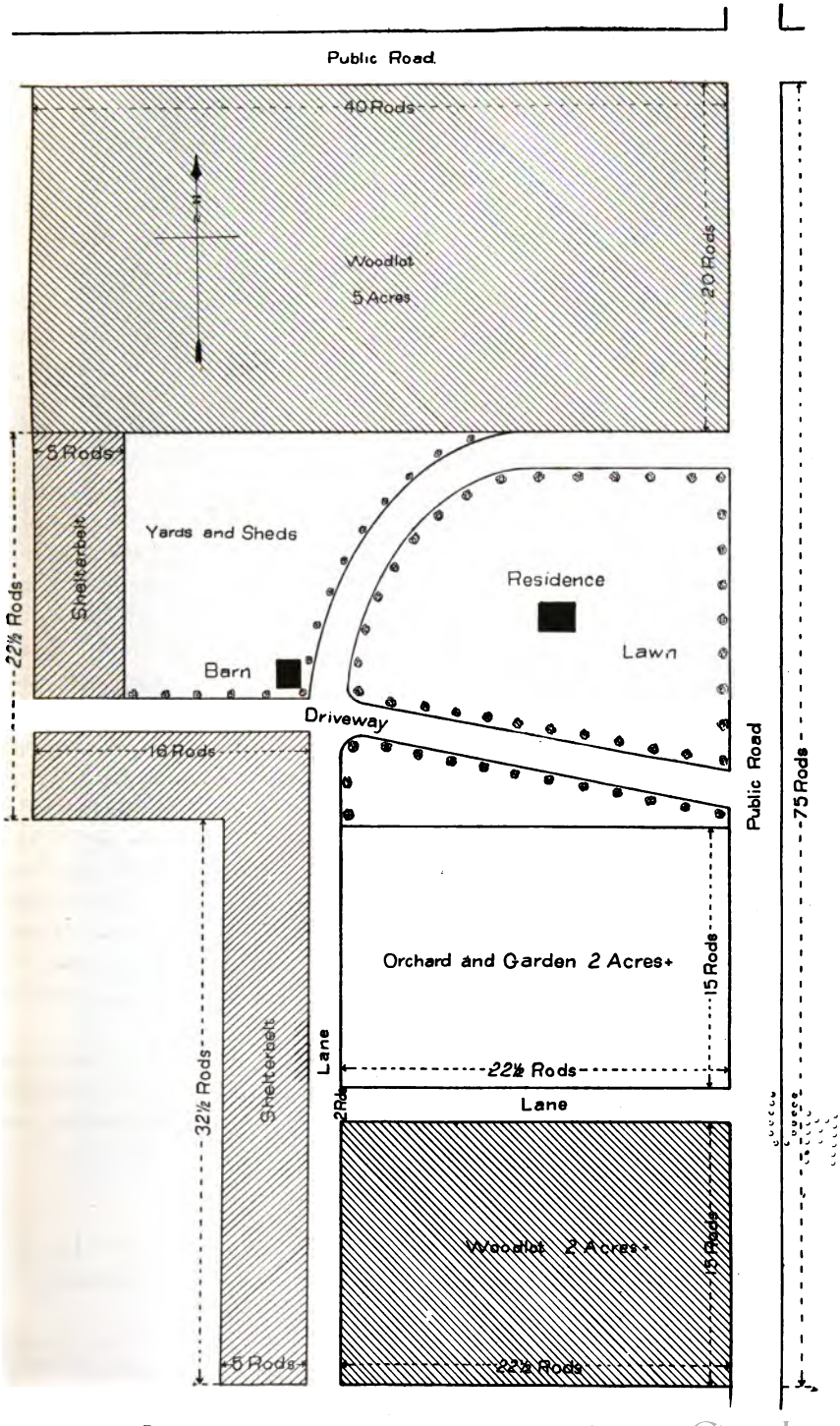
The pulverizing harrow is an excellent tool for shallow cultivation, and, used frequently enough, it is all that is necessary most of the time. Where weeds have made a good start, an ordinary cultivator may be put in, or a shallow disking given, but the disk should be followed by a harrow to produce proper surface conditions.

After the trees are planted a plow should never be used. Too often the plantation is neglected until weeds have formed a dense mass 3 or 4 feet high, and then, in desperation, a plow is resorted to, without subsequent harrowing. This leaves the ground rough, increasing greatly the loss of soil moisture through evaporation, and forms a dead furrow between the rows, or throws the earth away from the base of the trees, and cuts many roots, both injuring the root system and causing the growth of sprouts. The man who is not willing to take proper care of his trees deserves to lose them, and probably will.

The Rainbelt Experiment Station, at Cheyenne Wells, Colo., furnishes an excellent example of the extent to which cultivation can replace irrigation. This station was established in 1894 in a typical High Plains region. The elevation is 4,200 feet, with water 260 feet below the surface. The annual precipitation is about 13 inches. An apple orchard was planted in 1895 with trees of the varieties common farther east, such as Ben Davis, Janet, Winesap, etc., which are in excellent condition, and produce good fruit. The intention is to give two shallow cultivations monthly if possible. The tools used are a 5-tooth cultivator and a dagger-tooth harrow with the teeth set slanting. There are some green ash trees around the orchard a year older than the apple trees, which are thriving finely. Young honey locusts are also in promising condition. There is no doubt that under the same method of cultivation several forest species could be successfully grown.

The Pomeroy Model Farm, at Hill City, Kans., which has been practicing the "Campbell system" of cultivation since 1900, is a valuable experiment. While the main object is the production of wheat and other crops, fruit trees, Russian mulberry, silver maple, and white elm have been set out. They are doing finely so far, although it is a very unfavorable situation for the maple, and only fair for the elm. Cultivation is given after every rain as soon as the ground can be worked. A pulverizing harrow is generally used, preceded by a disk if the weeds have got too much of a start.

Cultivation should not be continued too late in the fall, for it tends to produce a growth of young shoots after the normal period, which may be too tender to withstand the winter. The wood should have time to harden before cold weather sets in. There is more likelihood



SKETCH OF PLANTATION FOR A FARMSTEAD ON NORTHEAST CORNER OF A SECTION.

SCOTCH PINE AT SMITH CENTER, KANS., PLANTED SIXTEEN YEARS.
Diameter, breasthigh, 5.6 inches.

Growth of valley or watered black walnut.

Place.	How standing.	Age.	Average height.	Average diameter breast-high.	Time required to grow 1 inch in diameter breasthigh.	Number of trees measured.
		Years.	*Feet.*	*Inches.*	*Years.*	
Byron, Okla	Grove	8	16	3.1	2.6	22
Danbury, Nebr	...do	12	16	3.4	3.5	38
Greensburg, Kans	Row	14	16	6.2	2.3	7
St. John, Kans	...do	16	18	3.2	5.0	20
Danbury, Nebr	Grove	17	28	8.2	2.1	14
Beaver City, Nebr	...do	20	22	4.1	4.9	8
Great Bend, Kans	Row	20	25	9.0	2.2	30

HARDY CATALPA.

Catalpa may be expected to thrive in western Kansas in localities where permanent water occurs at a depth of 10 to 20 feet under a sandy loam soil. Since its chief value is for posts, there is little use in planting it outside the territory where it grows rapidly and makes profitable returns.

Growth of valley or watered hardy catalpa.

Place.	How standing.	Age.	Average height.	Average diameter breast-high.	Time required to grow 1 inch in diameter breasthigh.	Number of trees measured.
		Years.	*Feet.*	*Inches.*	*Years.*	
Ashland, Kans	Park	10	20	5.7	1.8	10
Oberlin, Kans	Row	12	18	6.1	2.0	6
St. John, Kans	Grove	12	24	7.2	1.7	20
Stockton, Kans	Row	15	20	5.8	2.6	9
Beaver City, Nebr	...do	16	22	5.2	3.1	5
Kinsley, Kans	Grove	17	22	5.2	3.3	10
Beaver City, Nebr	...do	17	15	5.8	2.9	10
Meade, Kans	...do	18	25	3.6	5.0	10

AILANTHUS.

The ailanthus is of Chinese origin. The wonderful claims made for it when first introduced have scarcely been justified so far as western Kansas is concerned. Thousands of trees were set in timber claims and elsewhere, but those which succeeded are few. The ailanthus grows rapidly, is not very particular as to soil, and is capable of withstanding considerable drought and neglect, but it winterkills badly while young. Trees which manage to get past this stage seem to have no further trouble. Were it not for this tenderness, alianthus would do very well, but even then it would hardly deserve preference over several species whose especial fitness has been proved.

Ailanthus flourishes in other regions, and is considered a good street tree. The trunk is smooth and symmetical, the foliage luxuriant and tropical looking, and city smoke and dust harm it little.

BUR OAK.

Natural bur oak extends well westward, so it must be counted as one of the more hardy species, though little used for planting. Occasional thrifty specimens are found in the valleys, and there is no doubt that success would result from more extensive trials. Several species of more value are doing so well on the upland, however, that there is no chance for the bur oak to equal them, and only variety is to be gained by experimenting with it.

POPLARS.

The white and Lombardy poplars are closely related to the cottonwood, but are less hardy. They will succeed in many valley situations, but their value is slight.

White poplar, sometimes erroneously called "silver maple," is a nuisance, because of the numerous sprouts from the roots, and unless protected from the wind generally stands slanting instead of straight.

Lombardy poplar has admirers on account of its tall, slender form; but it, too, suckers from the roots, and is short-lived as well. When the numerous lateral branches begin to die, all the beauty the tree once had quickly disappears.

WILD CHINA.

The wild China, or chinaberry, is a native of southern Kansas and the Southwest, so it has become inured to aridity. It is a small tree with grayish bark, rather delicate compound leaves, and characteristic clusters of translucent, golden berries containing black seeds. It is hardy, and an excellent tree for occasional use in ornamental planting. Wild China is also called "soapberry," since the berries of a closely allied species are used in the place of soap.

RUSSIAN OLIVE.

Russian wild olive, or oleaster, is a hardy tree of small size that will evidently succeed over most of the State, though it has been little planted as yet. More extensive trials in Nebraska and South Dakota show it to be an excellent species for hedges and windbreaks in dry regions. The growth is rapid and the grayish foliage pleasing in appearance.

OTHER SPECIES.

Sycamore and coffeetree have been planted very little, but are excellent for ornamental purposes. The former makes a particularly good street tree. Both can be grown to a considerable extent in the Arkansas Valley and similar situations.

Blue spruce is considered to be hardy, but has not yet been planted sufficiently to warrant conclusions.

A few planters who are familiar with it think that Chinese arborvitæ will give excellent results when more extensively tried.

There is no doubt that as time goes on valuable new species will be introduced and forest trees will be planted in increasing numbers. The field for experiment is large, and many problems are yet to be solved.

SUMMARY.

Some of the leading conclusions of this bulletin are briefly recapitulated. They are points which should be borne in mind by the tree planter in western Kansas.

The effect of forest planting on climate is problematical as to increased precipitation, but definitely determined as to its favorable results in the conservation of moisture and checking the wind.

The results to be obtained are sufficient to justify the expenditure of time and labor, and it is useless to expect success without such efforts. An intelligent selection of species, followed by good care, is essential. Not every man can set trees and make them prosper. Consequently it often happens that one thriving plantation tells more of the inherent possibilities of a given region than do a dozen failures.

The planting should be carefully done in all cases, but conifers require unusual care. For ordinary plantations the best practice is to use small trees and home-grown seedlings so far as possible.

Cultivation is essential to success, and should be such as to conserve the largest possible amount of soil moisture.

Whether to prune or not depends entirely upon the kind of tree and the purpose of the plantation. The best time to prune is in early spring, just before growth begins. The cuts should be clean and close to the trunk.

To a hitherto unappreciated extent cultivation can be made to replace irrigation or natural supplies of moisture; but, nevertheless, upland and lowland planting should be treated as distinct problems, as regards both the choice of species and the period for which cultivation should be given. It is likewise true that every species presents problems of its own, which must be worked out if the highest efficiency is to be obtained.

All planting, whether shelterbelt, ornamental, or commercial, should be for a definite purpose, and the most suitable trees chosen accordingly. The time for the temporary planting of rapid growing, short-lived species is passing, except in special cases. That of the future should be of a permanent character and such as will give lasting benefit, even though not so quickly.

BOTANICAL NAMES OF TREES MENTIONED.

Austrian pine	*Pinus laricio austriaca* Endl.
Scotch pine	*Pinus sylvestris* Linn.
Blue spruce	*Picea parryana* (André) Parry.
Chinese arborvitæ	*Thuya orientalis* Linn.
Red cedar	*Juniperus virginiana* Linn.
Black walnut	*Juglans nigra* Linn.
Willows	*Salix* sp.
Cottonwood	*Populus deltoides* Marsh.
White poplar	*Populus alba* Linn.
Lombardy poplar	*Populus nigra italica* Du Roi.
Bur oak	*Quercus macrocarpa* Michx.
White elm	*Ulmus americana* Linn.
Hackberry	*Celtis occidentalis* Linn.
Russian mulberry	*Morus alba tatarica* (Linn.) Loud.
Osage orange	*Toxylon pomiferum* Raf.
Sycamore	*Platanus occidentalis* Linn.
Honey locust	*Gleditsia triacanthos* Linn.
Coffeetree	*Gymnocladus dioicus* (Linn.) Koch.
Black locust	*Robinia pseudacacia* Linn.
Ailanthus	*Ailanthus glandulosa* Desf.
Silver maple	*Acer saccharinum* Linn.
Boxelder	*Acer negundo* Linn.
Wild China	*Sapindus marginatus* Willd.
Green ash	*Fraxinus lanceolata* Borkh.
Russian wild olive	*Elæagnus angustifolia* Linn.
Hardy catalpa	*Catalpa speciosa* Warder.